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| APPLICATION NO.   | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO.     | CONFIRMATION NO. |
|---|-------------|----------------------|-------------------------|------------------|
| 10/812,347  | 03/30/2004  | Fumihiko Higuchi     | 071469-0307558 (ES-038) | 2682             |
| 7590  | 08/01/2008  |                      | EXAMINER                |                  |
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|   |             |                      | ART UNIT                | PAPER NUMBER     |
|   |             |                      | 1792                    |                  |
|   |             |                      | MAIL DATE               |                  |
|   |             |                      | 08/01/2008              | DELIVERY MODE    |
|   |             |                      |                         | PAPER            |

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UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE BOARD OF PATENT APPEALS  
AND INTERFERENCES

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*Ex parte* FUMIHIKO HIGUCHI,  
HIROYUKI TAKAHASHI, AKITERU KO,  
HONGYU YUE, ASAON YAMASHITA,  
and HIROMITSU KAMBARA

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Appeal 2008-1606  
Application 10/812,347  
Technology Center 1700

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Decided: July 31, 2008

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Before BRADLEY R. GARRIS, CHARLES F. WARREN, and  
ROMULO H. DELMENDO, *Administrative Patent Judges*.

WARREN, *Administrative Patent Judge*.

DECISION ON APPEAL

Applicants appeal to the Board from the decision of the Primary Examiner finally rejecting claims 1 through 22 and 24 through 29 in the Office Action mailed June 7, 2006 (Office Action). 35 U.S.C. §§ 6 and 134(a) (2002); 37 C.F.R. § 41.31(a) (2006).

We affirm the decision of the Primary Examiner.

Claims 1 and 29 illustrate Appellants' invention of a method for achieving a trim amount of a feature on a substrate in a chemical oxide removal process, and are representative of the claims on appeal:

1. A method for achieving a trim amount of a feature on a substrate in a chemical oxide removal process comprising:

setting a process recipe for said chemical oxide removal process, wherein said setting said process recipe comprises setting an amount of a first process gas, and setting an amount of a second process gas;

determining a relationship between a trim amount of said feature and an amount of an inert gas, wherein said relationship is established for an amount of a first process gas, and an amount of a second process gas;

adjusting said process recipe for said chemical oxide removal process in order to achieve said trim amount by setting an amount of the inert gas;

chemically treating said feature on said substrate by exposing said substrate using said process recipe; and

substantially removing said trim amount from said feature, wherein said determining said relationship includes curve-fitting either said trim amount data as a function of said amount of said inert gas or said amount of said inert gas as a function of said trim amount data.

29. A method for achieving a trim amount of a silicon oxide feature on a substrate in a chemical oxide removal process comprising:

setting a process recipe for said chemical oxide removal process, wherein said setting said process recipe comprises setting an amount of HF, and setting an amount of NH<sub>3</sub>;

adjusting said process recipe for said chemical oxide removal process in order to achieve said trim amount by setting an amount of argon;

chemically treating said feature on said substrate by exposing said substrate using said process recipe, wherein said amount of HF is introduced independently from said amount of said NH<sub>3</sub>, and said amount of argon is introduced with said amount of NH<sub>3</sub>; and

substantially removing said trim amount from said feature, wherein increasing said amount of argon corresponds to decreasing said trim amount.

The Examiner relies upon the evidence in these references (Ans. 2):

|          |                    |               |
|----------|--------------------|---------------|
| Natzle   | US 2004/0097047 A1 | May 20, 2004  |
| Newton   | US 2004/0099377 A1 | May 27, 2004  |
| Tomoyasu | US 2004/0185583 A1 | Sep. 23, 2004 |
| Doris    | US 2004/0241981 A1 | Dec. 2, 2004  |

Appellants request review of the following grounds of rejection under 35 U.S.C. § 103(a) advanced on appeal (Br. 6-7<sup>1</sup>):

claims 1 through 22 and 24 through 29 over Tomoyasu (Ans. 3);

claims 1, 4 through 8, 10 through 12, 15 through 19, 21, 22, and 24 through 28 over Newton (Ans. 5);

claim 1, 4 through 12, 15 through 22, and 24 through 29 over Natzle in view of Newton (Ans. 6); and

claim 2, 3, 13, and 14 over Natzle in view of Newton as applied to claims 1 and 12, further in view of Doris (Ans. 5).

Appellants argue the claims in the grounds of rejection as a group, with additional argument with respect to independent claim 29 in the first and third grounds. Thus, we decide this appeal based on claims 1, 29, and 2. 37 C.F.R. § 41.37(c)(1)(vii) (2006).

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<sup>1</sup> We have numbered the pages of the Brief beginning with the title page.

The issues in this appeal are whether the Examiner has carried the burden of establishing a *prima facie* case in each of the grounds of rejection advanced on appeal.

The plain language of claim 1 specifies a method comprising at least the steps, *inter alia*, of setting any chemical oxide removal process (COR) recipe which comprises setting an amount of each of first and second process gases; determining any relationship between a trim amount of any feature on any substrate and any amount of an inert gas for the established amounts of the first and second process gases, wherein determining the relationship includes curve-fitting either said trim amount data as a function of said amount of said inert gas or said amount of said inert gas as a function of said trim amount data; and adjusting said COR recipe for a trim amount by setting the amount of the inert gas in applying the recipe to the substrate.

The plain language of claim 29 specifies a method comprising at least the steps, *inter alia*, setting any COR recipe which comprises setting an amount of each of HF and NH<sub>3</sub>; adjusting the recipe to achieve any trim amount by setting an amount of argon (Ar), where increasing the amount of Ar decreases the amount of the trim rate; and introducing HF separately from the combination of NH<sub>3</sub> and Ar in applying the recipe to any feature on any substrate. In other words, in these claims the amount of the reactant process gases, such as HF and NH<sub>3</sub>, are constant process parameters of the recipe while the amount of the inert gas, such as Ar, is a variable process parameter that is used to determine trim data which can be used to adjust the recipe to achieve a trim amount of a feature on a substrate.

We find Tomoyasu would have disclosed to one of ordinary skill in this art a method of operating a COR processing system which includes, *inter alia*, “performing at least one of setting, monitoring, and adjusting one or more chemical process parameters” for the system comprising “at least one of a chemical treatment processing pressure, . . . [a system component] temperature, and a chemical treatment gas flow rate; [and] processing the substrate . . . using the one or more chemical process parameters.”

Tomoyasu, Abstract and ¶ 0007; *see also* ¶¶ 0055-0056 and 0059. The system includes a COR module in which the COR reaction product is formed and a post heat treatment chamber in which the reaction product is evaporated. Tomoyasu, e.g., ¶¶ 0052, 0057-0058, and 0061.

The COR processing system has a number of components which provide process targets, recipe parameters, data gathering and analysis, including algorithms, and adjustment of the COR recipe applied to the substrate. Tomoyasu, e.g., ¶¶ 0029-0054 and 0075-00127, and Figs. 1-5. The system components establish the initial state of the wafer and the target state of the wafer with respect to critical dimensions, and uses the difference to “predict, select, or calculate a set of process parameters to achieve the desired result” with respect to that dimension. Tomoyasu ¶¶ 0063-0069 and 0085.

The system components “can compute a predicted state for the wafer based on the input state, the process characteristics, and a process model,” including “a trim rate model [that] can be used along with a processing time to compute a predicted trim amount” and “an etch rate model can be used along with a processing time to compute an etch depth,” using a number of

models. Tomoyasu ¶¶ 0072-0074; *see also* ¶ 0062. The system components use “measured actual process results . . . compared with the predicted process results in order to determine a correction to the process model,” as well as “[m]odel updates . . . by running monitor wafers, varying the process settings and observing the results” to update models. Tomoyasu ¶¶ 0077-0080.

Tomoyasu discloses an embodiment in which the COR recipe includes “a process gas comprising HF [(hydrogen fluoride)] and NH<sub>3</sub>” (ammonia), a processing pressure, gas flow rates, and system component temperature. Tomoyasu ¶¶ 0059-0060. The system includes a “process model [that] not only provides input parameters for gas flow rates but also provides input parameters for gas flow rate ratio.” Tomoyasu ¶ 0088. Tomoyasu illustrates chemical treatment system 1220 as including “delivery of a heat transfer gas . . . to the backside of substrate 1242 via a backside delivery system,” wherein “the heat transfer gas . . . can comprise an inert gas such as helium [(He)], argon [(Ar)], . . . a process gas such as CF<sub>4</sub>, . . . , or other gas such as oxygen, nitrogen, or hydrogen.” Tomoyasu ¶ 0195 and Figs. 15 and 16. Tomoyasu further illustrates chemical treatment system 1220 as including “a gas distribution system 1260 for distributing a process gas comprising at least two gases,” wherein “[t]he process gas can, for example, comprise NH<sub>3</sub>, HF, H<sub>2</sub>, O<sub>2</sub>, CO<sub>2</sub>, Ar, He, etc.” Tomoyasu ¶ 0200 and Figs. 15, 16, and 18.

We find Natzle would have disclosed to one of ordinary skill in this art a process of making MOSFET devices which includes a COR precleaning step that employs vapors of HF and NH<sub>3</sub> as reactants to form a

COR adsorbed reactant film under low pressure on silicon oxide as a self-limiting etch to strip the silicon oxide from a substrate, wherein the gas flow is controlled by valves and an exhaust pump. Natzle, e.g., Abstract and ¶¶ 0002, 0014, and 0037-0038. The COR adsorbed reactant film remains on the substrate surface while the vapor pressure of NH<sub>3</sub> and HF is near the vapor pressure at the temperature of the apparatus, and a reaction product comprising ammonium hexafluorosilicate ((NH<sub>4</sub>)<sub>2</sub>SiF<sub>6</sub>) is formed under the reactant film. Natzle, e.g., ¶ 0039-0042. The reaction product can be removed by evaporation in a heated chamber. Natzle, e.g., ¶ 0046.

The amount of silicon oxide removed from the substrate “is a function of the substrate temperature, composition and residence time of the adsorbed reactant film,” and “[f]actors influencing the amount removed per unit time include the vapor pressure of the reactant at the temperature of the substrate . . . ; the amount of reactant or the rate of reactant admitted to the COR chamber . . . ; the speed of [the vacuum] pump . . . ; and the reaction rate between the adsorbed reactant film . . . and the . . . silicon oxide layer,” all of which can be regulated. Natzle, e.g., ¶ 0042-45. “The self-limiting thickness [of the adsorbed layer] can be tuned by changing the reaction conditions,” including pressure, temperature in the reaction chamber, and the amount and mixture of reactive gases, each of which is controlled by separate feed lines. Natzle, e.g., ¶¶ 0047-0051 and 0106-0113.

We find Newton would have disclosed to one of ordinary skill in this art a COR process wherein a mixture of a first fluid, NH<sub>3</sub>, and a second fluid, HF, forms an adsorbed layer of ammonium bifluoride (NH<sub>5</sub>F<sub>2</sub>) on silicon oxide that reacts with the silicon oxide to form a self-limiting

etchable layer of  $(\text{NH}_4)_2\text{SiF}_6$  that can be removed by thermal desorption. Newton, e.g., Abstract and ¶ 0026. In addition to thermal desorption, the layer of  $(\text{NH}_4)_2\text{SiF}_6$  can be removed by rinsing in a solvent, such as water. Newton ¶ 0030.

A stoichiometric number of moles of HF to  $\text{NH}_3$  is reacted to obtain  $\text{NH}_5\text{F}_2$ , providing a molar ratio of the gases which controls the amount of silicon oxide that is etched, and thus should be provided uniformly and homogeneously on the substrate being etched. Newton, e.g., ¶¶ 0027-0032, 0050, and 0057. Newton discloses an apparatus in which fluid feed lines 97, 99 regulate the flow of “[t]he first fluid [which] may comprise, inter alia, ammonia . . . and the second fluid [which] may comprise inter alia, hydrogen fluoride,” with the fluid feed lines “alternatively provided with inter alia Argon or nitrogen gas.” Newton, e.g., ¶ 0033 and Figs. 1-2; see also ¶ 0074. The thickness of the self-limiting etchable layer can be controlled such that a specific etch rate change/minute can be directly proportional to temperature. Newton, e.g., ¶¶ 0047 and 0050. “A thickness of the self-limiting etchable layer . . . was controlled by varying the temperature of the workpiece . . . resulting in controlling a reaction temperature between the HF and  $\text{NH}_3$ , or by altering the HF: $\text{NH}_3$  stoichiometry,” and [i]t was determined that a change of  $1\text{A}^\circ\text{C}$ . equals

$17\text{\AA}, <<$  of etch rate change/minute” when the workpiece temperature was maintained “from about -10 to about  $90\text{\AA}^\circ\text{C}$ .” Newton ¶ 0073.

We find Doris would have disclosed to one of ordinary skill in this art a COR process wherein a mixture of HF and  $\text{NH}_3$  forms a solid reaction

product with silicon oxide that can be removed by evaporation and rinsing the structure in water. Doris ¶¶ 0045-46.

We determine the Examiner has made out a *prima facie* case of obviousness with respect to each of the grounds of rejection based on the Examiner's findings from the applied references and the conclusions based thereon as set forth in the Answer (Ans. in entirety), and remain of that opinion upon reconsideration of the record as a whole in light of Appellants' contentions. We add the following to the Examiner's position for emphasis.

With respect to the rejection of claims 1 and 29 over Tomoyasu, the Examiner concludes the teachings of Tomoyasu would have led one of ordinary skill in this art to include an inert gas, such as Ar, with the reactant gases NH<sub>3</sub> and HF to achieve a trim amount of a silicon oxide feature on a substrate. Ans. 3. The Examiner further concludes it would have been obvious to this person from Tomoyasu that the process parameters of the flow rate of at least two reactant gases, the flow rate of inert gases, and the process pressure exerted by the gases are result-effective variables. Thus, this person would have analyzed trim amount data obtained from routine experimentation using an inert gas as a variable parameter and reactive gases as a constant parameter for a relationship between the trim amount and the amount of inert gas to select and adjust COR recipes in conjunction with trim amount data and the variable parameter to obtain optimal results with respect to predictable trim amounts when the recipe is applied to a substrate. Ans. 3-4. In this respect, the Examiner concludes the use of analytical tools by Tomoyasu would have led this person to use curve fitting and polynomial expressions to determine the relationship. Ans. 3.

We note here the Examiner finds that curve-fitting a relationship between different data is a common engineering and statistical method. Office Action 4, 6, and 8; Ans. 3, 5-6, and 8. Appellants do not dispute the Examiner's finding. Br. in entirety. *See, e.g., In re Ahlert*, 424 F.2d 1088, 1091 (CCPA 1970) ("Where the appellant has failed to challenge a fact judicially noticed and it is clear that he has been amply apprised of such finding so as to have the opportunity to make such challenge, the board's finding will be considered conclusive by this court.").

Appellants submit the teachings of Tomoyasu with respect to the use of inert gas in heat transfer gas in ¶ 0195 and in process gas in ¶ 0200 do not disclose a relationship between a trim amount and an amount of inert gas as claimed. Br. 11. In this respect, Appellants contend there is no suggestion in Tomoyasu that "trim rate models used to compute predicted trim amount . . . are based on any relationship other than trim amounts and processing 'reactive' gases (i.e., HF or NH<sub>3</sub>).” Br. 11. Appellants further contend Tomoyasu does not teach setting an amount of Ar in order to achieve a trim amount where increasing the amount of Ar decreases the trim amount, or the introduction of Ar with NH<sub>3</sub> and independent of HF as specified in claim 29.

We cannot agree with Appellants' contentions because we determine Tomoyasu would have disclosed to one of ordinary skill in the art that the at least two process gases used in the COR recipes is not limited to reactant gases, such as HF and NH<sub>3</sub>, but includes inert gases, such as Ar, and both reactant gases and inert gases can be combined for distribution in Tomoyasu's COR processing system, as the Examiner points out. Ans.

9-10; *see also above* p. 5. Thus, we determine this person would have readily distinguished between the use of Ar as a process gas and as a component in a heat transfer gas in the teachings of Tomoyasu.

We further determine one of ordinary skill in this art would have known that the use of inert gas adjusts the flow and amount of a reactant gas in a system, and in this relationship, each gas provides a partial pressure as the Examiner points out. Ans. 9-10; *see above* pp. 6-7. Thus, contrary to Appellants' contentions, this person would have reasonably inferred that Tomoyasu includes combinations of reactant and inert gases in the "processing pressure" and "flow rate" chemical process parameters such that the trim rate models used to predict trim amounts of silicon oxide are based on a relationship that includes reactive gases as diluted with inert gases.<sup>2</sup> In this respect, one of ordinary skill in this art would have reasonably recognized that increasing the amount of inert gas, such as Ar, in a reactive gas flow, such as with HF and NH<sub>3</sub> added separately, would decrease the trim amount, regardless of the reactive gas to which the AR is added.

Accordingly, on this record, we are of the opinion that the Examiner has established that, *prima facie*, one of ordinary skill in this art routinely following Tomoyasu alone would have reasonably arrived at the claimed method for achieving a trim amount of a feature on a substrate in a COR process encompassed by claims 1 and 29 without resort to Appellants'

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<sup>2</sup> It is well settled that a reference stands for all of the specific teachings thereof as well as the inferences one of ordinary skill in this art would have reasonably been expected to draw therefrom, *see In re Fritch*, 972 F.2d 1260, 1264-65 (Fed. Cir. 1992); *In re Preda*, 401 F.2d 825, 826 (CCPA

Specification. *See, e.g., KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1740-41 (2007) quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) (“[A]nalysis [of whether the subject matter of a claim would have been obvious] need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ.”); *Sovish*, 769 F.2d at 743 (skill is presumed on the part of one of ordinary skill in the art); *In re Bozek*, 416 F.2d 1385, 1390 (CCPA 1969) (“Having established that this knowledge was in the art, the examiner could then properly rely, as put forth by the solicitor, on a conclusion of obviousness ‘from common knowledge and common sense of the person of ordinary skill in the art without any specific hint or suggestion in a particular reference.’”); *see also In re O'Farrell*, 853 F.2d 894, 903-04 (Fed. Cir. 1988) (“For obviousness under § 103, all that is required is a reasonable expectation of success.” (citations omitted)).

Turning now to the ground of rejection of claim 1 over Newton alone, the Examiner concludes the teachings of Newton would have led one of ordinary skill in this art to set an amount of inert gas, such as Ar, with the reactant gases HF and NH<sub>3</sub> in order to achieve a trim amount, and determine a relationship on the trim amount and the amount of inert gas which can be curve fit according to a common engineering and statistical methods. Ans. 5-6.

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1968), presuming skill on the part of this person. *In re Sovish*, 769 F.2d 738, 743 (Fed. Cir. 1985).

Appellants submit that Newton's teachings of including an inert gas in fluid feed lines 97, 99 would not have led one of ordinary skill in this art to determine a relationship between the trim amount and the amount of inert gas via curve-fitting as claimed in claim 1. Br. 13-14.

We disagree with Appellants' contentions because, as we found above, one of ordinary skill in this art would have known that the use of inert gas adjusts the flow and amount of a reactant gas in a system, and in this relationship, each gas provides a partial pressure. *See above* p. 11. Thus, this person would have recognized from Newton's disclosure that the inert gas provided to fluid feed lines 97, 99 regulates the flow of the reactant gas, thereby varying the HF:NH<sub>3</sub> stoichiometry parameter, including partial pressure, and thus controlling the amount of silicon oxide that is etched over time to achieve a specific etch rate per unit of time. Therefore, this person would have further recognized a relationship between the trim amount and the amount of inert gas included with the reactant gases and reasonably would have applied common engineering and statistical methods, including curve-fitting, to analyze the relationship.

Accordingly, on this record, we are of the opinion that the Examiner has established that, *prima facie*, one of ordinary skill in this art routinely following the teachings of Newton would have reasonably arrived at the claimed method for achieving a trim amount of a feature on a substrate in a COR process encompassed by claim 1 without resort to Appellants' Specification. *See, e.g., KSR Int'l*, 127 S. Ct. at 1740-41 (*quoting Kahn*, 441 F.3d at 988); *Sovish*, 769 F.2d at 743; *Bozek*, 416 F.2d at 1390; *see also O'Farrell*, 853 F.2d at 903-04.

Turning now to the ground of rejection of claims 1 and 29 over the combined teachings of Natzle and Newton, the Examiner concludes Natzle would have led one of ordinary skill in this art to set the amounts of two reactant gases in an COR recipe wherein trim amount data can be acquired for the process parameters of reactant gas vapor pressure and flow rate, all of which can be regulated. Ans. 7. The Examiner further concludes this person would have combined an inert gas with Natzle's reactive gases as taught by Newton with respect to COR processes, and would have determined a relationship between a trim amount and an amount of an inert gas which can be curve fit according to a common engineering and statistical methods..

Ans. 7-8.

Appellants, relying on the same reasons submitted with respect to the ground of rejection based on Newton alone, submit that Natzle does not teach or suggest the use of inert gases and nothing in Newton suggests the relationship between the trim amount and the amount of inert gas via curve-fitting as claimed in claim 1, or setting of an amount of Ar as claimed in claim 29. Br. 14-16.

We found above that, contrary to Appellants' contentions, one of ordinary skill in this art would have adjusted the flow and amount of a reactant gas in a system with inert gas which provides its own partial pressure. *See above* p. 11. We remain of the view that this person would have recognized from Newton's disclosure that the inert gas would have that effect in varying the HF:NH<sub>3</sub> stoichiometry parameter as disclosed in this reference. *See above* pp. 13-14. Thus, the evidence in Newton supports the Examiner's position.

Accordingly, on this record, we are of the opinion that the Examiner has established that, *prima facie*, one of ordinary skill in this art routinely following the combined teachings of Natzle and Newton would have reasonably arrived at the claimed method for achieving a trim amount of a feature on a substrate in a COR process encompassed by claim 1 without resort to Appellants' Specification. *See, e.g., KSR Int'l*, 127 S. Ct. at 1740-41 (*quoting Kahn*, 441 F.3d at 988); *In re Keller*, 642 F.2d 413, 425 (CCPA 1981)((“[T]he test [for obviousness] is what the combined teachings of the references would have suggested to those of ordinary skill in the art.”); *Sovish*, 769 F.2d at 743; *Bozek*, 416 F.2d at 1390; *see also O'Farrell*, 853 F.2d at 903-04.

With respect to the ground of rejection of claim 2 over the combined teachings of Natzle, Newton, and Doris, Appellants rely on the reasons submitted with respect to claims 1 and 29 (Br. 16) which does not address the thrust of the Examiner's rejection applying Doris. Ans. 8. Thus, Appellants have not rebutted the Examiner's *prima facie* case of obviousness.

Accordingly, based on our consideration of the totality of the record before us, we have weighed the evidence of obviousness found in Tomoyasu, Newton alone, the combined teachings of Natzle and Newton, and the combined teachings of Natzle, Newton, and Doris, with Appellants' countervailing evidence of and argument for nonobviousness and conclude that the claimed invention encompassed by appealed claims 1 through 22 and 24 through 29 would have been obvious as a matter of law under 35 U.S.C. § 103(a).

Appeal 2008-1606  
Application 10/812,347

The Primary Examiner's decision is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED

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